SMASS AND SMASSIR: VISIBLE AND NEAR-INFRARED SPECTRAL STUDIES OF MAIN-BELT AND NEAR-EARTH ASTEROIDS

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Introduction. Visible and near-infrared spectroscopy are the most widely applied techniques for inferring the mineralogical composition of main-belt and near-Earth asteroids. Minerals that are commonly found in meteorites (e.g., olivine, pyroxene) have diagnostic absorption features in these wavelength regions. The two most notable surveys in the 1980s to measure the spectral characteristics of large numbers of asteroids were the Eight-Color Asteroid Survey (ECAS) [1] and the 52-color survey [2]. ECAS observed 589 objects in the visible while the 52-color survey measured ~120 objects in the near-infrared (~0.9 to ~2.5 µm). ECAS data are the basis for the asteroid taxonomy [3] that is used today, while 52-color data are the basis for the subdivision of the S-class into seven subgroups [4] that contain members with apparently different mineralogic compositions. However, both surveys could only make measurements of asteroids with diameters greater than ~20 km.

SMASS I and II. The Small Main-belt Asteroid Spectroscopic Survey (SMASS) was initiated at MIT in 1990 with the goal of obtaining spectra in the visible for a substantial number of small (diameters < 20 km) asteroids in the inner (< 2.6 AU) main belt. The initial results (SMASS I) [5] were published in 1995 and included the spectra of 316 different asteroids. Significant results from this survey include the discovery of objects in the Vesta family and between Vesta and the 3:1 resonance with Vesta-like spectra [6] and one asteroid (3628 Boznemcová) with an unusual spectrum that is similar to the spectra of some ordinary chondrites [7].

The second stage of this survey (SMASS II) [8] is currently underway. As of January of 1997, SMASS II has currently observed more than 900 objects. Significant results from this survey include the discovery of a number of near-Earth asteroids with spectra similar to some ordinary chondrites [9] and the identification of a spectral similarity between individual family members for eleven different asteroid families [10]. A list of observed SMASS I and II objects may be found at http://web.mit.edu/thb/www/smass/smass.html.

Unanswered Questions. Spectral surveys in the visible can roughly identify the presence or absence of minerals such as olivine and pyroxene since both minerals have a characteristic absorption feature centered between ~0.9 and ~1.0 µm (called the 1.0 µm band). To do a more definitive mineralogical characterization of an asteroid, near-infrared data are needed to further define the characteristics of the 1 µm band and to identify the presence or absence of the characteristic 2 µm band due to pyroxene. Near-infrared data allows for relative amounts of olivine and pyroxene on the surface of an asteroid to be roughly determined [4].

SMASS has identified many objects with "unusual" visible spectra. For example, 3628 Boznemcová has very strong ultraviolet and 1 µm features [7]. However, it is impossible to accurately determine the mineralogic composition without further defining the structure of the 1 µm band. Also, some S-asteroids have been found [5] to have no appreciable 1 µm bands and have been proposed to have similar compositions to some postulated "spinel-rich" asteroids [11] that only have a 2 µm feature with no corresponding 1 µm band. Near-infrared data are needed to determine the presence or absence of this 2 µm band to further define the composition of these objects. Near-infrared data are also particularly important for trying to determine the number of olivine-dominated asteroids in the main belt [12] and the overall spectral similarity of objects with visible spectra comparable to ordinary chondrites (some near-Earth asteroids, 3628 Boznemcová, etc.) [13].

SMASSIR. To complement SMASS, a program (SMASSIR) to make near-infrared observations of small main-belt and near-Earth asteroids is currently being established. These measurements are to be done at the NASA Infrared Telescope Facility (IRTF) on Mauna Kea using the NSFCAM detector. An asteroid grism with appropriate blocking filters is being designed and tested to record a simultaneous first-order spectrum from ~0.9 to ~1.7 µm with a dispersion of ~0.015 µm per pixel. This wavelength region overlaps the visible CCD coverage of SMASS. The predicted V-magnitude limit is 17.5.

The main expected advantage of this system, compared to the 52-color survey, is that fainter, and therefore smaller, objects can be observed. The main expected disadvantage is that the wavelength coverage only extends out to ~1.7 µm, compared to ~2.5 µm for the 52-color survey. The SMASSIR coverage will allow for the 1 µm band center (where the continuum is removed) to be accurately determined, which is a function of the olivine/pyroxene composition. It should be also possible to recognize the presence (or absence) of a 2 µm feature due to pyroxene (or spinel), however, it will be impossible to completely characterize this feature due to the limited wavelength coverage relative to the 52-color survey.

Conclusions. SMASSIR should allow for near-infrared measurements to be taken on a significant fraction of small main-belt and near-Earth asteroids. By understanding the spectral properties of these objects, it should be possible to gain a better insight on the compositional structure of the main belt. Many "unusual" objects have been discovered in SMASS and near-infrared observations will allow for their surface compositions to be better characterized.

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